A SEMINAR ON

# An Architecture Combining Blockchain, Docker and Cloud Storage for Improving Digital Processes in Cloud Manufacturing

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# CONTENTS

# 1. INTRODUCTION

- **Blockchain** – It is a decentralized, distributed, peer-to-peer system used to record transactions across many computers so that the record cannot be altered.
- **Docker** – It is a software platform that allows you to build, test, and deploy applications quickly using containers that have everything the software needs to run including libraries, code, etc.
- **Cloud Storage** – It is a data storage in which the data is stored in across multiple servers and the physical environment is typically owned by a company.
- **Digital Processes** – It refers to those software tasks that has to be performed using the system.
- **Cloud Manufacturing** – It is a service-oriented business model to share manufacturing capabilities and resources on a cloud platform.

# 2. RELATED WORKS

| Authors | Proposed System | Date |
|---|---|---|
| J. Leng, S. Ye, M. Zhou, J. L. Zhao, Q. Liu, W. Guo, W. Cao, and L. Fu | Blockchain-secured Smart Manufacturing in Industry 4.0 | Jan 2020 |
| A. Haridas, A. A. Samad, D. Vysakh, and V. Pathari | A Blockchain based platform for Smart Contracts and Intellectual Property Protection for the Additive Manufacturing Industry | Mar 2022 |

# 3. MAIN TECHNIQUE

- This paper introduces  a novel approach for implementing BPM in Blockchain by using the features of two of the most popular cloud technologies: Docker and Cloud Storage.
- Docker is used in the process execution phase, supposed that the process to be executed is a digital process.
- The inputs and outputs are stored in a traditional cloud storage and we use Blockchain and Smart Contracts for process implementation and monitoring.
- We also introduce a basic task assignment problem based on execution time prediction performed through an ANN trained with past process runs metrics.

## 3.1 COMPONENTS

- There are five main components in the proposed platform:
  - Process Owner
  - Process Consumer
  - Process Runner
  - Permission Granting Application (PGA)
  - Data Mining Algorithm

## 3.1 COMPONENTS (contd.)

- **Process Owner -** It represents the entity that creates the process core logic and codes the algorithm. It packs the algorithm to a docker file and executes CreateProcess.
- **Process Consumer -** It represents the entity that needs to perform an instance of the digital process for its business purposes.
- **Process Runner -** It provides the computational resources to execute the process instance by running the related image in a container.
- **Permissions Granting Application -** This component assigns and revokes permissions on files in the cloud storage.
- **Data Mining Algorithm** – It collects past instances metrics and trains the execution time prediction ANN for each runner on a regular time basis.

## 3.2 SMART CONTRACTS

- The whole process life cycle rely on two smart contracts developed using Solidity.
  - **Process Smart Contract** – It stores data of processes, runners and instances. In addition, it provides CreateProcess and ProcessInstance functions that, in the proposed platform, represent the two main transactions of the Blockchain.
  - **Oracle Smart Contract** – It is used to store the calculated weights of each ANN trained on past instance metrics. The weights are updated on a regular time basis.

## 3.2 SMART CONTRACTS (contd.)

- ProcessInstance function selects the fastest ProcessRunner by predicting the execution time for each registered available runner.
- If it accepts, it is immediately granted the needed permissions on the cloud Storage by the PGA to retrieve the instance inputs.
- Once the inputs are available, the process instance is executed in a docker container with the requested image.
- At the end of the execution, the smart contract is notified and the outputs are stored on the cloud storage to be finally retrieved by the consumer.

# 3.3 PLATFORM ARCHITECTURE

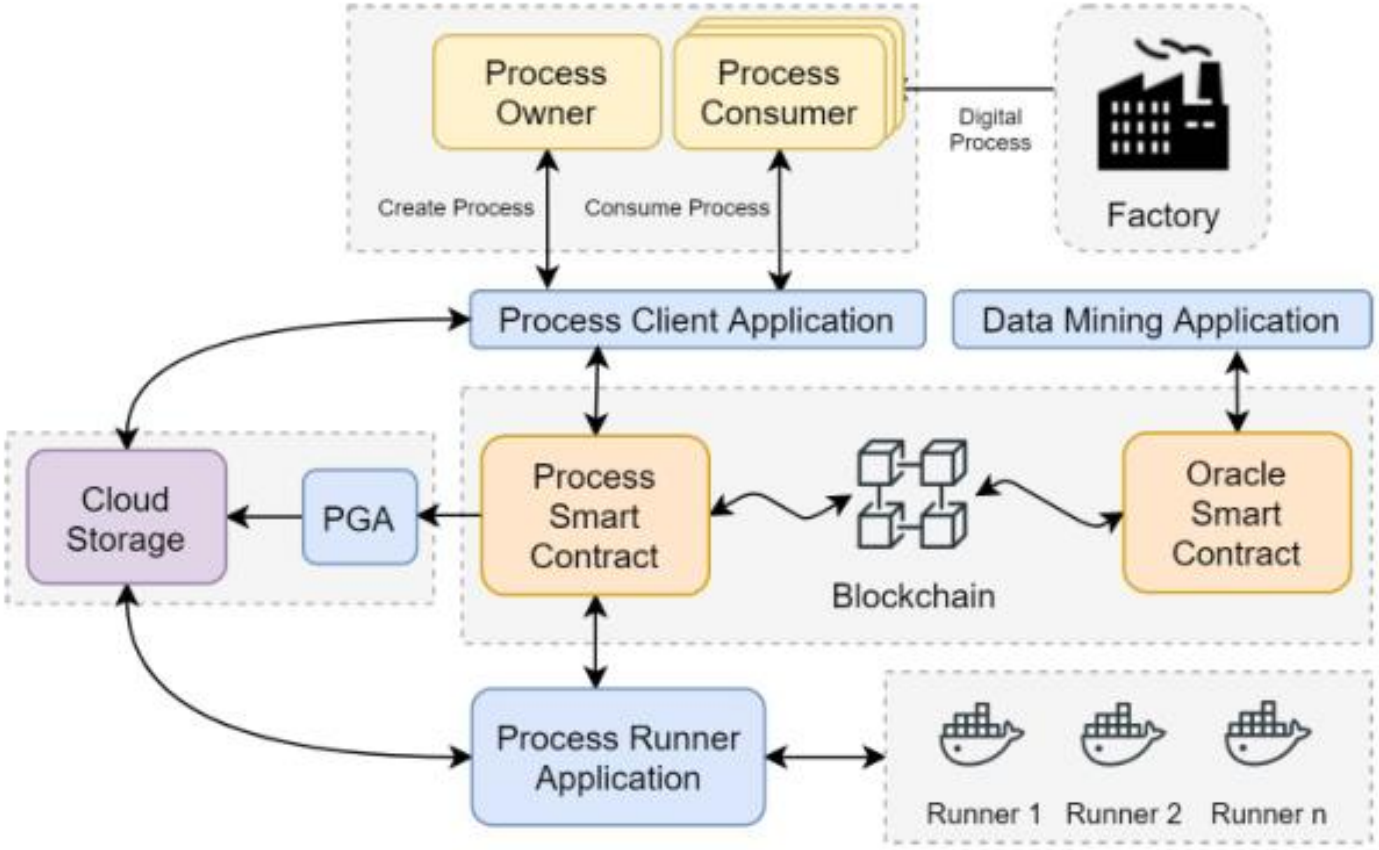
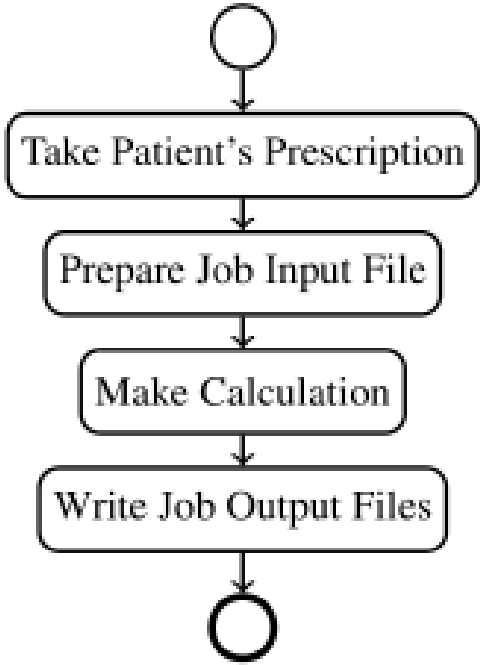



**FIGURE 1.** Platform architecture & use cases.

# 3.4 OPHTHALMIC LENSES MANUFACTURING (CASE STUDY)

- The process of lens manufacturing is typically made of five steps in sequence: Calculation, in which the lens surface to be machined is computed, Surfacing, Polishing, Coating and, finally, Edging.
- In this work, we focus on Calculation, which is a pure digital process. A typical lens calculation software is called Lens Design System (LDS).
- A LDS takes the patient's ophthalmic prescription as input and performs a mathematical calculation that produces the data to be sent to a CNC machine to realize a surface on the back of a semi-finished lens.

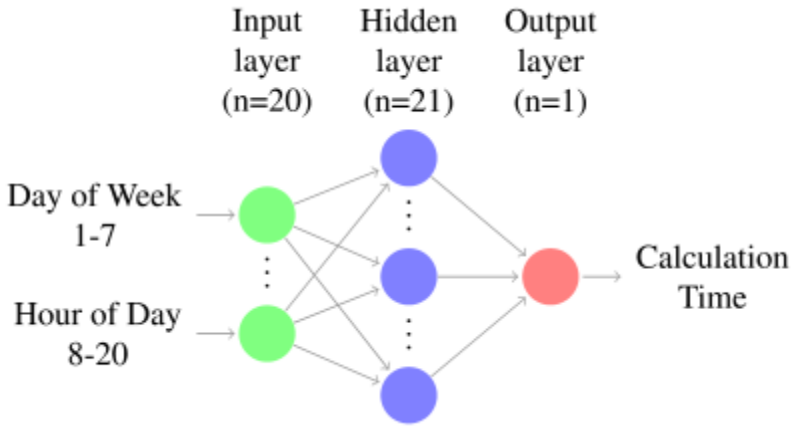


## 3.4 CASE STUDY (contd.)

- Firstly, we identify the actors of the case study as follows: Process Owner is the Lens Designer, Process Consumer is the Lens Manufacturer and Process Runner is the Surface Calculator.
- Lens Designer implements its calculation algorithm with the programming language of his choice and packs the compiled application along with all libraries and dependencies in a Docker image.
- Consequently, the implementation of CreateProcess and ConsumeProcess functions for respectively adding new lens design and requesting new calculation.
- Process Client Application is connected to the lens manufacturer’s information system to allow the CNC machine to retrieve the calculated surface.

## 3.4 CASE STUDY (contd.)

- Data Mining Application collects metrics from past lens calculation instances and trains a model for each runner and for each process to predict the running time of a single lens design instance on the runner at a specified time.
- After generating the dataset, we build the ANN. The resulting network consists of 20 neurons in the input layer, 21 neurons in the hidden layer and a single neuron in the output layer which represents the calculation time.



# 4. PERFORMANCE EVALUVATION

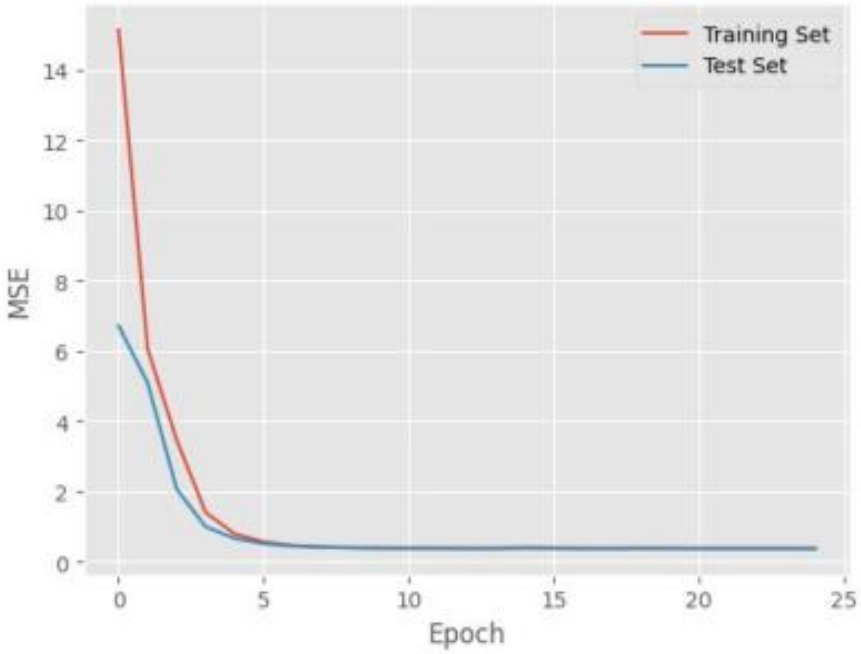



**FIGURE 5.** Training Epochs vs. MSE.

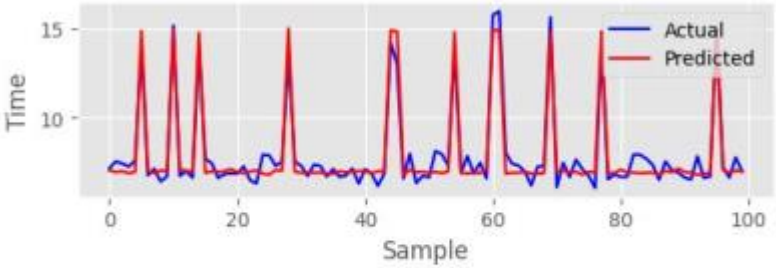



**FIGURE 6.** Effectiveness of the time prediction ANN.

# 4. PERFORMANCE EVALUVATION (contd.)

- By implementing an LDS system in the proposed Blockchain platform, the following improvements are achieved over existing systems like ProCrea.
    - **Collaboration** - It provides a shared and decentralized platform on which multiple Lens Designers can make their algorithms available in form of self-contained Docker images. The integration of new or updated designs is therefore easier, as it does not require any structural change or any significant reconfiguration of the environment.
    - **Performance** - The provided solution is distributed and fault tolerant. The manufacturer can run multiple calculations, that are executed simultaneously on different runners.

# 4. PERFORMANCE EVALUVATION (contd.)

- **Cybersecurity** - Since the Blockchain is tamper-proof, the economic transactions of the fees charged to the manufacturer and paid to lens designers and surface calculators cannot be altered.
- **Costs** - Since the cloud storage service has typically low fares, a long term storage is guaranteed for input and output files. This feature also prevents data loss on manufacturer’s side.

# 5. CONCLUSION

- In short, this paper presents s a novel platform for improving digital processes in a Blockchain environment in which we integrate two of the most popular cloud technologies: Docker and Cloud Storage.
- We identify and describe the roles of Process Owner, Process Consumer and Process Runner.
- A simple task assignment problem, implemented through an ANN approach, is also introduced for the purpose of improving the performance by decreasing instances execution times.
- Finally, we provide a case study regarding the implementation of this platform in Ophthalmic Lenses Manufacturing environment and specifically in Lens Design Systems.

# 6. REFERENCES


- A. Haridas, A. A. Samad, D. Vysakh, and V. Pathari, "*A Blockchain-based platform for Smart Contracts and Intellectual Property Protection for the Additive Manufacturing Industry*", IEEE Int. Conf. Signal Process., Informat., Commun. Energy Syst., Mar 2022.
- J. Leng, S. Ye, M. Zhou, J. L. Zhao, Q. Liu, W. Guo, W. Cao, and L. Fu, "*Blockchain-secured Smart Manufacturing in Industry 4.0*", IEEE Trans. Syst., Man, Cybern., Syst, Jan 2020.
- T. Hewa, A. Braeken, M. Liyanage, and M. Ylianttila, "*Fog Computing and Blockchain-based Security Service Architecture for Industrial IoT- enabled Cloud Manufacturing*", IEEE Trans. Ind. Informat., Oct. 2022.